

Planetary Science Subcommittee Meeting, October 2-3, 2012

National Aeronautics and Space Administration
Washington, D.C.

NASA ADVISORY COUNCIL

PLANETARY SCIENCE SUBCOMMITTEE

October 2-3, 2012
NASA Headquarters
Washington, D.C.

Meeting Minutes

Jonathan Rall, Executive Secretary

Janet Luhmann, Chair

*Report prepared by
Joan Zimmermann, Zantech IT*

Planetary Science Subcommittee Meeting, October 2-3, 2012

Table of Contents

| | |
|-----------------------------------|---|
| Welcome | 3 |
| Planetary Science Division Update | 3 |

Appendix A- Attendees
Appendix B- Membership roster
Appendix C- Presentations
Appendix D- Agenda

Planetary Science Subcommittee Meeting, October 2-3, 2012

October 2, 2012

Welcome and Administrative Matters

Dr. Janet Luhmann, Chair of the Planetary Science Subcommittee (PSS), opened the meeting and made introductions around the room. Ms. Joan Salute sat in for Dr. James Green, Director of the Planetary Science Division (PSD). Dr. Jonathan Rall, Executive Secretary of the PSS, reviewed some administrative rules.

Planetary Science Division Update

Ms. Salute presented a status of the division, beginning with a winning video clip celebrating the Venus Transit, a result of a contest sponsored by PSD. Ninety-second (maximum) video clips time capsules were submitted to this contest, entitled *Dear Citizens of 2117*. All 47 submitted videos are available on the NASA website. PSD is continuing to reap the public relations benefits of the successful landing of Curiosity on Mars. Ms. Salute highlighted a moving letter from 20-year-old Isaac Larkin to President Barack Obama, describing how inspired he had been by this great achievement.

In the budgetary arena, a Continuing Resolution (CR) has been passed with no specific instructions for PSD, therefore the Division will remain at FY12 levels. PSD is limited to spending at less than or equal to \$1.19B per year from October 2012 until a final Appropriations bill is passed. PSD cannot spend at a higher rate until the CR expires, despite some optimistic anticipation of an increased Division budget.

OSIRIS-REx and InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) are the newest planetary missions, along with NASA participation in JUICE, a European Space Agency (ESA) mission to Jupiter. MAVEN, a Mars aeronomy mission, is scheduled to launch in November 2012, and LADEE, an investigation of the lunar dust environment, has a launch date in 2013. OSIRIS-REx is a New Frontiers (NF) project, scheduled to be launched in September 2016 to perform an asteroid sample return mission. InSight, a Mars stationary lander mission, is the newest Discovery selection, and is not part of the Mars Exploration Program (MEP).

NASA is currently planning to pay the full cost of a domestic Pu-238 production project. This year the project is in a planning phase, with a sample product expected next year. The Discovery 12 selection, InSight, does not use an Advanced Stirling Radioisotope Generator (ASRG), but PSD is still building two flight units for 2016 according to the original schedule guidelines. The Department of Energy (DOE) had some issues with normal flight project risks associated with the ASRGs, which have created some delay. Ms. Salute noted that PSD must await final decisions on the NASA budget in order to make firm commitments for future ASRG planning. A NASA Headquarters representative commented that the ASRG delay had nothing to do with the Discovery selection, and had it been a NASA-designed review, the project would have passed. The Discovery reviews occurred before the August decision to delay the ASRGs. Asked if ASRGs would be permitted on the next NF call, Ms. Salute responded the expectation is that NASA will have access to ASRGs in 2016, preferably flight-tested before the NF call.

Future opportunities

Progress is being made in the ESA JUICE mission, planned for launch in 2022, arriving at Jupiter in 2030. NASA has committed to \$100M total in instrument support for this mission and has received 9 proposals. Review panels will be meeting in October, and proposals are being reviewed by both NASA and ESA. These are PI-led projects, with selection expected in late January 2013.

NASA has issued a new charter for the NASA Lunar Science Institute (NLSI), expanding its scope to include near-Earth asteroids and the Mars moons, Phobos and Deimos. PSD is also assessing the potential of planetary science as studied from a Stratospheric Balloon; this is an opportunity for producing good science at lower cost, and to train young scientists. PSD initiated a study on the balloon platform, held a community workshop in January 2012, and identified 41 specific science studies. The effort has received very positive community feedback. There will be an open workshop in early 2013 to assess the National Reconnaissance Organization's proffered telescope assets. Until now, a NASA team led by Alan Dressler had been working in a classified environment to evaluate the telescope. The telescope has great potential and capability for Astrophysics, and while there is no budget for it at present, the workshop will consider how this asset can support NASA science across the Science Mission Directorate (SMD). A symposium marking NASA's 50 years of exploring the Solar System will be held in Crystal City, VA on 14 October. In coordination with this symposium is a public event that requires ticket procurement through the National Geographic Society. The event will be webcast as well, featuring "Science Guy" Bill Nye moderating a panel discussion of planetary scientists. Asked about rumors of a possible sequestration in January 2013, Ms. Salute commented that SMD had no plans in place; however a meeting participant noted that White House directives would prevail in such an event. Dr. Charles Shearer asked if LSI would be including nodes for Astrophysics and Heliophysics, Ms. Salute noted that Heliophysics has provided some funding, but Astrophysics has not. Dr. Julia Castillo-Rogez asked if there was an interest in PSD for nanosats or cubesats. Dr. Mary Voytek responded that there are no immediate plans for announcements of opportunity (AOs) for small satellites, however a fair amount of O/OREOS nanosatellite technology has been developed for the International Space Station. Dr. Rall responded to further questions about sequestration, noting that in Research and Analysis (R&A), PSD will be planning to the current budget, resulting in a reduction of selection rates for the time being; relevant budget data is embargoed at this time.

Mars Exploration Program

Mr. Douglas McCuistion presented the latest program developments in MEP, first noting that MAVEN is making good progress, and is on budget and ahead of schedule for launch. The Mars Program Planning Group (MPPG) report is complete, representing one of the inputs to formulation planning for the Planning, Programming, Budget and Execution (PPBE14) process for FY14. The InSight mission is being managed by the Discovery program, and will include MEP Program Executive (PE) Dr. Ramon dePaula, who was also the PE for Phoenix. The reconstruction of the Mars Science Laboratory (MSL) Curiosity rover's entry, descent and landing (EDL) is being initiated, and will be preserved as a bound document. Various Lessons Learned (LL) activities are being carried out on subjects such as MSL instrument development, etc. MEP recently held a Senior Review (SR) of ongoing Mars missions, based purely on the scientific value of various Mars missions, excluding assessment of the programmatic infrastructure. The Mars Odyssey orbiter is graded Yellow due to the loss of a reaction wheel just before MSL landing. Odyssey is operating on 2 primary wheels and a skew wheel. Its inertial

Planetary Science Subcommittee Meeting, October 2-3, 2012

measurement units (IMUs) are laser gyroscopes whose lifetimes are deteriorating as expected. The program shut off the lasers and is navigating in all-stellar mode to conserve laser lifetimes. The Opportunity rover is doing well, as is Mars Express, which has been extended to 2014.

The Opportunity rover is currently at the Cape York site on Mars, investigating “pseudoblueberries” as seen through a microscopic imager; these features are not the blueberry concretions found elsewhere, and do not have the iron content that “normal” blueberries have. The discovery is a perfect example of the value of extended missions. The Mars Reconnaissance Orbiter (MRO) has provided images of the shifting of the MSL EDL parachute on the surface over time. MRO communications support represents 28 GB of data so far, at a rate of 480 Mb/sol. MRO has been using an Adaptive Data Rate (ADR) technology, a software-reprogrammable radio that varies data rate based on quality of available links; ADR is now used for all MRO passes.

Plan forward

MPPG results were briefed to SMD at the end of August 2012; consequently, MEP/PSD is developing an architecture that will be recommended to NASA and OMB during the PPBE14 process, thus NASA’s reformulation plan for Mars will be embargoed for the time being. NASA is aiming to get these plans drafted early in October/November to enable a 2018 opportunity, in anticipation of the budget announcement in February 2013. A 2018 mission is not guaranteed and will be a challenge. In mid- to late October, NASA will meet with the Office of Management and Budget (OMB), and get a passback in late November. February/March will be the timeframe in which to engage the community on a reformulated MEP. In response to several questions, Mr. McCuistion felt there could be anywhere from 2-4 SDTs required for the re-planning process, which will be planned to the FY12 budget. Dr. Luhmann asked if MEP planned any coordination with Discovery missions that go to Mars. Mr. McCuistion responded that he not yet met with Dr. Green on the matter, but noted that InSight’s science objectives are not directly in line with the “follow the water” theme; in that respect the Decadal Survey did not influence the selection. Dr. Luhmann commented that there was an advantage to including Scouts in the MEP. Mr. McCuistion agreed that Discovery is more removed from the MEP. In terms of ESA involvement with MEP, there are PIs involved in the program, including a co-I on the ExoMars NOMAD instrument, and there has been some discussion of cooperation for the 2018 opportunity, as well as instrument work at the Goddard Space Flight Center (GSFC). Relationships with ESA are still very good. Dr. Sanjay Limaye observed that India has announced a mission to Mars slated for November 2013; Mr. McCuistion noted that NASA has reached out to the Indian space agency (ISRO) but has not received an answer to date. He added that there is great community interest in reconvening an international Mars Exploration Working Group (iMEWG). MEP is committed to keeping Mars data analysis programs going forward, and is still involved in ExoMars discussions, but at much lower levels. ESA continues to show interest in securing NASA assistance in telecommunications and EDL for ExoMars.

Mr. McCuistion reported briefly on MSL statistics. The first contact science has been performed with the rover’s hand-lens tool; and evidence of an ancient streambed has been found. Curiosity landed at the edge of an alluvial fan, and is heading to a site named Glenelg to examine the joining of cratered, fractured and hummocky terrains. The rover will reach the site in 20-30 days, and will be searching for places to scoop and sieve while en route.

MSL/Curiosity Update

Dr. James Bell presented a detailed briefing on initial results from MSL, on sol 56 of the mission. MSL has been a phenomenal mission thus far, while much instrument checkout is still ongoing. The rover's goal is to explore and quantitatively assess the Mars surface as a potential habitat for life, past or present. Curiosity will explore biological potential, geology and geochemistry, and surface radiation conditions (as feed-forward data for human exploration). The rover has a complex payload and requires a more complex planning process, much like the Cassini mission, sharing limited resources with a highly competent payload. Curiosity will explore Gale Crater and Mount Sharp for evidence of possible aqueous transport, phyllosilicates, sulfates, and hydrated minerals. The 150-km Gale crater contains a 5-km-high mound of stratified rock. The base of the mountain dates back to the Noachian period, the earliest period in Mars history.

Images from the rover have revealed bedrock that was uncovered by the scouring action of the rover's retrorockets; initial results indicate that the surface was not modified/"baked" by rocket heat. The revealed bedrock resembles conglomerate found on Earth, and the rover has also seen these features well away from the scour sites. Curiosity has an excellent telephoto capability, and has been able to provide images of buttes, canyons and the layers of Mt. Sharp. There are 8 Gb of flash memory in each camera to support the creation of high-resolution panoramas. The Mars Hand-Lens Imager (MAHLI) has been used to examine various rocks and terrain features, and ChemCam (laser-induced breakdown spectroscopy) has provided some characterization of a feature called "Coronation," showing emission lines from plasma in UV through the visible and IR spectrum. Initial measurements have been made with the APXS (alpha-particle x-ray spectrometer). Dr. Bell displayed nested images of 25-cm "Jake Matijevic" rock, the first APXS contact, which is being used to cross-calibrate ChemCam and APXS; there will be an announcement of these results within a couple of weeks. Radiation Assessment Detector (RAD) measurements are being pulled together as well. The Environmental Monitoring Station is making temperature and pressure measurements continually; atmospheric pressure at Mars has not been well sampled since the Viking mission.

The Dynamic Albedo of Neutrons (DAN) instrument is being used to survey the upper meter of the surface as the rover drives along, "sounding" for hydrogen. Curiosity has been covering 20-30 meters/day, slowing down a bit to accommodate rockier terrain. Sedimentary geologists on the team are convinced that streambeds in this terrain once carried water that had been ankle-to-knee deep, and transported pebbles for kilometers of distance. The findings imply that water had been at the site for a significant amount of geologic time.

Dr. Bell displayed an image of a sand-dune-like ripple from sol 55, from which the rover would be taking measurements shortly. Asked about public engagement tracking, Dr. Bell reported that there are project staff assigned to this task, and that he himself checks YouTube, Reddit, etc. He noted that the infamous "We're NASA and We Know It" went viral. Dr. Bell addressed concerns about data dissemination vs. internal scrutiny to play by the rules of science, with respect to the images. All imaging goes to the web in near-real time as jpegs, thereby introducing the risk of getting scooped. From a science perspective, however, judging the experience from the Spirit and Opportunity rover missions, there appears to be collegial understanding of how to treat the data. On the public engagement side, it is much more important to release images quickly. Dr. Shearer asked if any specific textural/mineralogical class features had been identified yet. Dr. Bell reported that there is no true mineralogical information yet, but elementary composition data are being processed. Extremely fine-layered rock has been seen at Glenelg, and there is also imagery of polygonally fractured features.

Planetary Science Subcommittee Meeting, October 2-3, 2012

MPPG Briefing

Dr. Orlando Figueroa provided a summary of the final report of the MPPG, particularly acknowledging Mike Wargo and George Tahu for their support of the effort. MPPG was initiated in March 2012, precipitated by the Decadal Survey, the President's 2012 budget, and the POTUS challenge for humans at Mars in the 2030s. The MPPG team was comprised of a set of community experts. MPPG was chartered to provide options in light of critical boundary conditions such as budget, the imperative for international collaboration with particular attention to 2018/20 opportunities, and responsiveness to the Decadal Survey. Mr. Figueroa noted that the 2018/20 opportunity has been expanded to 2022 on the basis of budget factors. Other parameters considered include the energetically favorable Mars opportunity in 2018, the state of Mars infrastructure, and EDL/surface science operations competencies.

The MPPG approach to planning retained the key features of the highly successful and resilient Mars 2000 Plan, and its end goal is to achieve the greater strategy of integrating the Human Exploration and Operations Mission Directorate (HEOMD), SMD and the Office of the Chief Technologist (OCT)/Space Technology Program. MPPG explored multiple options within the trade space while being responsive to the Decadal Survey and integrating the necessary features.

Science pathways were focused on sequence of missions and on strategic vs. stand-alone missions (such as Scout missions like Phoenix or MAVEN) that are no longer in the Mars Program. Based on the Decadal Survey/MEPAG report, MPPG took another look at pathways: signs of past life, modern environments as habitats, dynamics/interior and Mars Systems Science. The latter three categories were regarded as being more suitable for a Discovery/NF competition. The search for signs of past life, as a pathway to sample return via in situ analysis and mobile, landed assets, was regarded as providing the highest priority science.

Community experts strongly advocated that any line of inquiry not aligned with seeking past signs of life be openly competed payloads on MEP strategic missions, or stand-alone missions in the Discovery program, and judged on the basis of scientific merit. MPPG took into account that years of searching for past life are now bearing fruit. Orbital reconnaissance and discovery of new settings are also ongoing. Mr. Mike Wargo of HEOMD commented that the maturity aspect of the pathway was a driving issue, and also considered that the Discovery/NF program has a higher probability for maturing Pathway B, a multi-rover plan for sample return.

An LPI workshop was held to explore Mars Concepts and Approaches. The workshop was wildly successful, defined key challenges for NASA, and received 390 abstracts from 10 participating countries. Several science themes influenced thinking, expanded the trade space, including concepts for extreme-terrain vehicles. Concepts were presented for cubesats to complement and augment orbital and surface platforms. Concepts took into account the collaboration between HEOMD, SMD and OCT, to prepare Mars for human landing: building up system capabilities, and gaining deep space operational experience. HEOMD/OCT intersection represents an early opportunity for collaboration, perhaps in having astronauts play a role in facilitating sample return. It is also an opportunity to identify knowledge gap-filling activities; demonstration of human mission-relevant, subscale surface access technologies; and demonstration of human mission-relevant deep space technologies.

Types of collaboration were defined as clean-interface collaborations (payloads, strategic knowledge gaps or SKGs, demonstrations) and interdependent collaborations. Current capabilities and forward work were also addressed. A MEPAG Precursor Science Analysis Group (P-SAG) looked at options such as science payloads on the planned Space Launch System (SLS), which may provide a single-shot Mars Sample Return (MSR) opportunity via a secondary

Planetary Science Subcommittee Meeting, October 2-3, 2012

payload. Solar electric propulsion (SEP) was also considered as a means of propulsion. Another opportunity considered was an MSR and return during early crewed operations beyond Earth orbit, removing the need to robotically “break the chain” of contact with returned samples, as required by Planetary Protection. The team determined intersections and opportunities through the 2020s and 2030s, and identified SMD/STP technology efforts with HEOMD benefit. Key technologies of interest to all three parties are EDL, in situ resource utilization (ISRU), and Mars Ascent.

MPPG determined that there are five functional elements to MSR: Infrastructure, Sampling, Retrieval, Return and Receiving, and considered one to three launches to achieve this goal. Pathway A1 is a multi-mission path, with 3-4 launches. Pathway A2 uses two launches and provides an integrated sampling scheme. Pathway B is a multisite investigation before MSR, using multiple rovers. The common aspects of all pathways are maintenance of heritage, taking advantage of guided-entry EDL; incorporating Sky-crane; incorporating innovative ideas; and reducing the mass of the Mars Ascent Vehicle (MAV).

Four options were considered for rover design. Rover A is a MER clone; Rover B is a higher-volume Rover A; Rover C is an MSL-derived design; and Rover D is a rover with an integrated MAV. The sample mass considered is in the sub-kilogram range, as mass is constrained by the budget. Rover concepts included cost estimates; Rover C is estimated to cost \$1.3 to 1.7B. An estimate for Rover D is ongoing. Phase E is not included in cost estimates. Launch vehicle costs are based on Falcon 9 or Atlas V data from the NASA Launch Services Office; these are prices derived from the most recent NASA Launch Services (NLS II) contract.

A number of orbiter concepts were considered, including one that is relay-only, as well as a combination of traditional science and relay orbiters; SEP sample-return schemes; and round-trip sample return with both science and relay orbiters. MPPG also considered the effects of the aging infrastructure at Mars. MPPG has provided cost summaries to NASA for sample missions from 2018-24, at varying levels of cost estimate fidelity. Arguments for an orbiter-first approach beginning in 2018 include the provision of an infrastructure for all subsequent landed missions; in addition, the President’s current budget does not support a rover. Arguments for rover first include the fact that 2018 provides the best energetic opportunity and is a logical follow-up to MSL. If opportunities for 2018/20 are omitted in order to accumulate budget, one loses the energetic favorability. Mr. McCuiston added that the 2022 time frame would be dependent on orbiter assets, and that the budget profile is not conducive to a 2018 opportunity.

MPPG provided sample options for strategic collaboration, and also carried out a high-level assessment of various benefits. Regarding international options, Mr. Figueroa commented that it became an impossible task to trace lines of authority to data. However, MPPG has collected relevant information and it will be transmitted to future efforts.

In summary, the return of Mars samples to Beyond Earth Orbit (BEO) offers an early intersection of robotic and human flight programs. All opportunities represent about a 50% reduction in costs as compared with Decadal Survey recommendations. The bulk of early planning/funding responsibility resides in SMD; HEOMD will enter the process only when humans become involved. Mr. Figueroa expected funding to come from relevant parties when they come to the table. Dr. Louise Prockter commented that human exploration and MSR appears to be a forced marriage; NASA is not using resources as well as it could. Mr. Figueroa responded that MPPG had been seeking a way to forge lasting collaborations while addressing science priority questions; humans are not just going to Mars to retrieve samples. He added that he had received encouragement from the directors of SMD and HEOMD. Dr. Limaye commented that much more

Planetary Science Subcommittee Meeting, October 2-3, 2012

work would be necessary, particularly in defining commitments from Congress to fund the effort through 2024. Mr. Figueroa reported that OMB was present at many of the MPPG discussions, as well as Congressional staff. In response to a question, he noted that the concept of astronauts at Lagrange Point 2 had also been considered.

Europa Mission Concept Study Update

Dr. Dave Senske presented results of the most recent Europa mission studies. Initial concepts for a de-scoped option for a Europa mission were presented to the Outer Planets Analysis Group (OPAG) in May 2012. Orbiter, clipper, and lander concepts were considered. The goal of the mission is to explore Europa and investigate its habitability; retaining the goals and objectives of the Jupiter Europa Orbiter (JEO) as recommended by the Decadal Survey. Objectives include determining the presence of water, chemistry constituents, and energy; the presence of the chemical disequilibrium required for metabolism, and to characterize Europa's ocean, ice shell, composition, and geology.

A study of an orbiter, originally released in May 2012, was designed to keep costs as low as possible and to place instruments on appropriate platforms. This design included 30 days in a 100-km, near-polar orbit, the performance of detailed global mapping, gravity and magnetic field measurements, and simple repetitive science operations. Cost was estimated at \$1.7B for phases A-E, excluding the cost of a launch vehicle (LV). Aerospace Corporation has validated this estimate. This particular orbiter concept did not examine the ice shell and composition.

Similarly, the original "clipper" concept, conceived as a orbiter that makes 32 low-altitude flybys of Europa over 2.3 years, included a detailed investigation of globally distributed regions of Europa and simple repetitive science operations, while excluding a characterization of Europa's ocean, at a total life cycle cost (LCC) of \$1.98B.

The original lander concept included 30 days of science investigation on Europa's surface; with surface and subsurface composition and morphology measurements, and autonomous precision landing technology required to mitigate unknown surface conditions. This was the least mature concept, at a cost of \$2.8B.

In general, the original studies sought to eliminate cost through reducing exposure to radiation, through such means as nested shielding, which eliminated the need for excessively radiation-hard parts. Instruments were reduced from 12 to 4 in number. Repetitive and simple operations, as well as modularity, increases schedule and test flexibility and enables smoothing of funding profile. The original orbiter concept was regarded as a very good, low risk mission. The original clipper was considered excellent and low-risk, while the original lander was considered excellent but high-risk. Reviewers concluded that the Clipper mission could be carried out in practical terms while providing the greatest public engagement and greatest science return per dollar.

NASA requested further studies for elucidation of enhanced orbiter science, enhanced clipper science (adding ocean science), landing site reconnaissance, and engineering trades (to investigate solar power options, the role of SLS, nanosats, e.g.). Programmatic needs were also considered in further studies, assessing the need for reconnaissance data from both science and engineering perspectives and safety of landing sites. It was determined that the assessment of at least 15 sites was necessary, including high-resolution imaging at 0.5 m/pixel, as well as thermal imaging to provide knowledge of properties of the surface.

Planetary Science Subcommittee Meeting, October 2-3, 2012

To date, NASA is now considering enhanced concepts for a Europa mission. The enhanced orbiter mission includes increasing the orbital duration to 109 days, making headway into understanding the ocean, as well as adding ice-penetrating radar to characterize the ice shell. The enhanced orbiter concept does not provide composition science, and is estimated at \$2.2B

Enhanced clipper science includes characterization of the ocean, magnetic induction response and amplitude and phase of gravitational tides. In terms of geology, the enhanced clipper mission expands the observation strategy to achieve global, regional, and local coverage (turning on the camera sooner than in previous concept). The clipper would be augmented with 3 instruments; a radio subsystem and independent gimballed antenna, a magnetometer and a Langmuir probe. Technical margins for this concept are good, but the cost is higher (\$2.2B). Alternate power sources, such as solar, are being considered. For the clipper, a solar array size of 60 m² would be required. A solar array could bring the cost back down to \$1.98B and is considered as a strong option. The Science Definition Team (SDT) agrees that an enhanced clipper is excellent in meeting science objectives, and subsequently the enhanced clipper has received a higher ranking than the enhanced orbiter concept, especially as it provides composition measurements.

In conclusion, all three Europa mission concepts are regarded as highly scientifically meritorious. Final reports are due in December. In the interim, presentations will be made to Dr. Green in November.

Discovery Mission InSight

Dr. Mitch Schulte presented a briefing on the progress of the most recent Discovery program selection, Interior Explorations Using Seismic Investigations, Geodesy and Heat Transport, or InSight. The selection was made in August 2012. Bruce Banerdt has been named as the Principal Investigator. The mission is scheduled for launch in March 2016, landing on Mars in September 2016, and is designed to perform surface operations for 720 Earth days, with instrument deployment at 60 sols, and a data volume over one Martian year of 29 Gb. The mission is designed to end in September 2018. InSight's goals are to understand the evolutionary formation of rocky planets, and the dynamics of Martian tectonics and meteorite impacts. Science goals are to determine the size, composition, and physical state of the Martian core; the thickness and structure of crust composition and the structure of the mantle; to measure internal seismic activity; and to measure the rate of meteorite impact.

The mission will use a focused set of measurements from a single-station seismometer installed on the surface, isolated from the environment (wind and temperature), which will carry out precision sub-decimeter X-band tracking. The lander can provide data on nutation and precession on Mars. A heat flow instrument will also be deployed; it is a self-penetrating "mole" that will penetrate to 3-5 meters below the surface. The flight system will be Phoenix-like, with only minor changes required, proven procedures and personnel, fewer instruments with a simpler science mission. CNES and DLR will be providing the two primary instruments. The mission can take advantage of multiple signal sources to study Phobos's tidal influence, impacts, faulting and atmospheric excitation. Present-day heat flow will yield a boundary condition on the thermal history of Mars. A reference landing site, Elysium Planitia, has been identified. The landing site is not driven by science, but planners are trying to avoid large rocks, or areas with rock abundance. Dr. Luhmann suggested the lander include a microphone as part of its payload.

PSD Senior Review status/outcome

Mr. William Knopf gave an overview of the PSD Senior Review process, marking the first time a consolidated review for PSD (including Mars missions) had been performed, resulting in a more complex review than that associated with other divisions. Guidelines were distributed to flight

Planetary Science Subcommittee Meeting, October 2-3, 2012

projects in January 2012 (with budget targets distributed on February 4, 2012). Criteria for evaluation were science and technical merit, with science weighted at 60%, and schedule. Selection of the review panel involved the Program Executives and Program Scientists of affected projects. The panel chair, Ray Walker, was solicited by Dr. Green. Dr. Walker had also chaired the most recent Heliophysics review. The review was held from 26-29 June; each proposal was discussed for an hour after each presentation, with two rounds of voting. In terms of final adjectival grades, Cassini ranked first (and was the only mission with an excellent rating), followed by LRO, MEX, MRO, MER, MEX/ASPERA-3, ODY, and DI-3. Science ratings were evaluated by deriving responses to a consistent set of questions, including technical queries about instrument/spacecraft health, etc. The review did not specifically address communication aspects of Mars assets. Extended-mission new critical science was proposed for each project.

Budget letters from the projects will be incorporated into the PPBE FY14 budget submission. An EPO update was requested in September, requesting that missions identify how each project can leverage the 50th Anniversary of Solar System Exploration. Next steps are to post results of the Chair's summary and panel findings, and to document Lessons Learned. Virtually every project received their guideline, except ASPERA-3, which received 85%. Dr. Sykes commented that a lack of transparency and forthrightness is perceived when the real numbers are not presented; the impact of operations on science can't be assessed without more precise budget information. Dr. Luhmann requested SR proposals for reading, if feasible and non-proprietary. Mr. Knopf reported that the Senior Review evaluations will be made public.

GPRRA discussion/voting

The subcommittee was instructed as to how to carry out Government Performance and Results Act (GPRRA) grading by Ms. Jennifer Kearns. The subcommittee assessed NASA's performance goals for PSD. Each science objective was evaluated in light of accomplishments of the past year; PSS then moved, seconded and voted for each goal to assign a color-coded grade.

Science Area Objective 1- *Inventory solar system objects and identify the processes active in and among them*

Vote- unanimous on Green

Science Area Objective 2- *Understand how the Sun's family of planets, satellites, and minor bodies originated and evolved*

Vote- unanimous on Green

Objective 3- *Understand the processes that determine the history and future of habitability of the environments on Mars and other solar system bodies*

Vote- unanimous on Green

Objective 4- *Understand the origin and evolution of Earth life and the biosphere to determine if there is or ever has been life elsewhere in the universe*

Vote unanimous on Green

Objective 5- *Identify and characterize small bodies and the properties of planetary environments that pose a threat to terrestrial life or exploration or provide potentially exploitable resources*

Vote- unanimous on Green

Planetary Science Subcommittee Meeting, October 2-3, 2012

October 3, 2012

Agenda Updates and Announcements

Dr. Rall agreed to use AG reports over the course of the year as a convenient source for collecting items for the GPRA report, as suggested by Dr. Voytek. Dr. Luhmann briefly discussed the most recent NAC Science Committee meeting, noting an interesting member dynamic, holistic vs. individualistic. She noted that broader topics tended to go forward, and that PSS should keep this in mind when making findings. The PI-led mission discussion was a good example of this phenomenon. Dissension tends to prevent some important issues from going up the chain to the NAC.

CAPTEM report

Dr. Mini Wadhwa reported the latest findings of the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), which allocates all materials except Antarctic meteorites. CAPTEM met in late September and plans its next meeting in March 2013. An *ad hoc* committee has been established for apportioning Stardust (Stardust IS Particles Ad Hoc Committee); one proposal has been received. Dr. Wadhwa reviewed allocations made since March 2012, adding that the first allocations of Hayabusa samples have been made available. The Japanese space agency (JAXA) has transferred only 15 particles from the Hayabusa mission thus far. A letter has been sent to JAXA on behalf of CAPTEM requesting transfer of uncharacterized samples (addressing the fear of contamination through analysis techniques). CAPTEM anticipates some action or response by the end of the year.

CAPTEM has reviewed a draft of Johnson Space Center Materials Office response to the Inspector General (IG) Report, and has provided inputs to the response. The IG has yet to provide feedback.

CAPTEM has established an Informatics Task Force in response to a White House memorandum. Together with the Meteorite Working Group, the new task force will develop a Strategic Plan for Informatics, representing the PI community in the development of external requirements.

CAPTEM has held workshops on both Dawn and Stardust data. Science highlights include observations of reduced carbon components of Martian salt, and the ubiquitous presence of abiotic carbon species. There were also papers on impact breccia from the Apollo 16 site, on late-forming chondrules in Comet Wild 2.

Current areas of concern for CAPTEM are the impact of the MPPG report on future plans for Mars Sample Return, project delays in Discovery and New Frontiers, AOs for the upcoming Senior Review, the impact of the NASA budget on R&A, and renegotiation with the National Science Foundation and the Smithsonian Institution on the curation and allocation of the Antarctic meteorite collection. Mentioning the possibility of the Lunar-Planetary conference being cancelled, Dr. Wadhwa was assured that this would not be the case by a Headquarters representative.

MEPAG

Dr. John Grant presented results of the latest Mars Exploration Program Analysis Group (MEPAG). Reviewing imagery of the MSL landing on 6 August, Dr. Grant noted that the importance of programmatic integration for a successful mission. Curiosity is currently examining a drift deposit, obtaining first samples, gathering data about the features of the terrain and characterizing the surroundings of Glenelg. The ultimate target of the rover is a 5-km pile of layered materials, where the rover will investigate more clay-bearing stratigraphy's and sulfate-

Planetary Science Subcommittee Meeting, October 2-3, 2012

bearing rock. It is hoped that by traversing these layers, one will be able read the chapters of Mars geological history, and to understand how the changes occurred and their implications for past habitability. All Mars missions were approved for extended missions in FY13-14, paving the way for exciting science objectives and new data products, including discovery of new surface deposits (potential brine flows and salt deposits), expanded coverage at high spatial resolution; characterization of pre-Noachian Mars; relay activities and monitoring for MER and MSL; and site characterization and certification capabilities for future Mars missions.

In the news, MRO's HiRise has provided clear images of MSL tracks. Recent findings of the MCS confirm the presence of dry ice at the Martian south pole. Odyssey's THEMIS has provided a thermal inertia map which delineates Gale Crater's alluvial fan, helping to piece together the story. The Opportunity rover is currently probing the Endeavour Rim for phyllosilicates. MAVEN mission planning remains on track, on schedule and on budget; its instruments are to be delivered in late 2012/early 2013. MEPAG appreciates the opportunity to have a non-strategic Mars mission in Discovery's InSight selection.

Recent activities within MEPAG include a teleconference with science members from MPPG to address Decadal Survey goals; MEPAG also provided input to MPPG from the Precursor-SAG, a group created to assess activities required to prepare for human exploration of Mars. The P-SAG final report has been delivered; its preliminary report on updated strategic knowledge gaps (SKGs) is posted the MEPAG website, where it can be linked to Lunar and Planetary Institute (LPI) activities. A diverse set of experts contributed to the P-SAG. P-SAG identified 17 SKGs associated with Human Exploration and Operations (HEO) goals, which include the first human mission to Mars orbit, the first human mission to Phobos and Deimos, the first human mission to Mars surface, and a sustained human presence on Mars. SKGs have been evaluated in terms of mission types, timing, etc.

Summary findings of the Precursor SAG (P-SAG)

- There are incomplete data and models for aerocapture and technology demonstrations
- A human mission to Phobos/Deimos would require a precursor mission to land on one or both moons
- An early robotic precursor program, needed to support a human mission to Mars, would consist of one orbiter, sample return, and a lander-rover based *in situ*
- There are 5 particularly important areas of overlap between HEO and science objectives: seeking signs of past life, seeking signs of present life, atmospheric dynamics, weather, dust, surface geology chemistry; and general exploration of Phobos/Deimos.

Dr. Grant noted that HEOMD, MEPAG and the Small Bodies Analysis Group (SBAG) share several high-priority measurement objectives in the Mars system. Of particular import are technology development/demonstration activities, and a comparative study need of the strategic value to Mars missions of water-based resources at various locations in the Solar System. It must also be determined whether a precursor sample return from Phobos/Deimos is truly necessary.

Future MEPAG meetings are to include a discussion of P-SAG, MPPG and MEP, the status of continuing missions, and early MSL science results. Goals set for the next MEPAG meeting are a discussion of budget and the joint P-SAG report, to capture community reaction to recent activities, and to discuss updates to the MEPAG Goals document. MEPAG is encouraged by Congressional support for restoring funding to the Mars program. MPPG pathways appear to be a reasonable way to capture options, and MEPAG encourages use of SAG reports for further consideration. Asked if P-SAG had considered the duration of human missions on the Mars

Planetary Science Subcommittee Meeting, October 2-3, 2012

surface, Dr. Grant replied that sustained presence has been interpreted as “months.” The ND-SAG (Next-Decade SAG), the MRR-iSAG (Mid-Range Rover, international SAG), and E2E-SAG (End-to-End sample return process SAG) are all working on this issue. The sense is that the P-SAG has shown that there is significant overlap between HEO and SMD, which could lead to robust exploration, as well as to provide answers to open questions. Dr. Des Marais observed that OCT has been attempting to identify cross-program initiatives that are critical to the effort, representing a foundation for developing initiatives into the Congressional budget process. Dr. Wargo addressed the next steps in addressing SKGs, noting that he had consulted with the LEAG, MEPAG and SBAG chairs on planning a joint SAG to look across the destinations and identify common elements and what is truly unique, as well as phasing information (when is the funding needed for a particular activity). The goal would be to lay out terms of reference (TOR) more formally to ensure that the job is done well. Asked if there were sufficient data for choosing a site for MSR, Dr. Grant replied that MEP has the assets needed to evaluate and certify sites for MSR; a number of sites have been identified from both a scientific and engineering perspective. The ongoing missions have already provided enough data for sample return, in Dr. Grant’s personal opinion. Dr. Rich Zurek agreed with this assessment, adding that validation would be necessary.

Dr. Luhmann requested information to bring to the NAC, while commenting that she sensed an attempt to put a positive spin on the potential impacts from President’s budget. Dr. Des Marais expressed a concern that the joint SMD/HEOMD/OCT initiative be given a way to go forward, to launch OCT in a significant way. Dr. Wargo agreed with this concern, adding that he felt the elements are in place, knowing that HEOMD is planning for these activities, having just signed a memorandum of understanding (MOU) to carry out joint precursor robotic activities; this activity has a limited budget, jointly supported by SMD and HEOMD. NASA will need a strategy for investing well, and needs to know what is important and when it is needed. Current support is \$10M from PSD and \$20M from HEOMD, some of which will likely be competed. The joint precursor robotic activities will be directed in terms of spacecraft, with an instrument AO. The next MEPAG meeting will be held on 4 October.

LEAG

Dr. Charles Shearer presented the latest results from the Lunar Exploration Analysis Group (LEAG). The group sponsored a summer workshop focused on the origin of the lunar crust, entitled the Second Conference on the Lunar Highlands Crust, along with CAPTEM, LPI and the NASA Lunar Science Institute (NLSI), including a field trip to a layered intrusion that may be analogous to some lunar features. The annual LEAG meeting will be in Greenbelt, MD, from 22-24 October, marking the 40th anniversary of the Apollo 17 mission. LEAG held a Town Hall meeting in March 2012, covering joint robotic precursor activities, an ESA robotic lander, LEAG past and future activities, and Stand-Alone Mission of Opportunity (SALMON) program interactions with Google XPrize. A Town Hall meeting was also held at the Lunar Forum conference in July 2012, dealing with SKGs for the Moon. LEAG Specific Action Team (SAT) activities results are now online; results from 3 subcommittees will be available shortly; including some results on investigations that could be performed at an Earth-Moon L2 facility. A GAP-SAT 2 committee has been addressing SKGs in lunar resources, lunar environment and its effects on human life, and understanding how to live and work on the lunar surface. This effort has also linked some of the SKGs with their overlap with the planetary Decadal Survey, and the LEAG Exploration Roadmap, to determine when the knowledge gaps could be filled (early vs. late in program).

Findings of the LEAG

- Following completion of the Lunar Reconnaissance Orbiter (LRO) mission, there are no SKGs inhibiting flight of an Apollo-type mission.
- In context of the “Moon-First” Scenario, a number of SKGs have been identified that would enhance the scenario.
- Resources and in situ resource utilization (ISRU) are regarded as game-changers in how humans can explore the Solar System.

Dr. Shearer noted the great variety of current lunar missions (LRO, GRAIL and ARTEMIS), and a variety of proposed or in-progress missions to the Moon, including three Chinese missions, NASA’s LADEE, and the Google Lunar XPrize efforts to put landers on the Moon’s surface by 2014. In 2020-22, many countries have aspirations to land on or orbit the Moon.

LEAG science results were presented. LRO has identified some fairly recent extensional tectonic features, such as grabens in the far-side highlands; observations suggest that a lunar magma ocean, if it existed, was not a result of whole-moon melting. LROC images of the Soviet Luna 24 sites have prompted re-examination of Luna samples to search for impact melt glass. LROC has provided images of sublunar voids, associated with mare basaltic magmatism, as well as high-resolution data on Tycho, helping to better understand cratering mechanisms. GRAIL has created a high-resolution “whole-Moon” gravity map, an order of magnitude more precise than the previous gravity model. Various planned international lunar missions were briefly touched upon, including two Russian missions to Moon: Luna Glob, and Luna Resource, a joint rover mission with India.

OPAG report

Dr. McKinnon presented results from the Outer Planets Analysis Group (OPAG), which last met in March 2012. The meeting was largely devoted to hearing reports from the Europa SDT. The JUICE mission announcement has resulted in a postponement of the planned September 2012 meeting to January 2013. Dr. McKinnon reviewed a number of OPAG findings.

Regarding Cassini’s extended mission, OPAG had issued a finding to strongly urge NASA to fund the Cassini Solstice mission at the level needed to safely operate the spacecraft and to obtain and analyze data required to accomplish the science objectives of the Solstice Mission; OPAG was gratified that the Senior Review agreed with this finding.

OPAG had urged meaningful participation in ESA’s JUICE (Jupiter Icy Moons Explorer) mission, and now applauds efforts of NASA, OMB and OSTP; the community is grateful that \$100M has been approved for participation in the mission. While the OP “baton” is being passed, OPAG recognizes that international collaboration remains strong and vital.

Concerning the President’s FY2013 budget, OPAG laments the reduction to PSD; OPAG urges PSD to restore the cadence of the PI-led Discovery and New Frontiers missions as recommended by the Decadal Survey. A falling tide grounds all boats and the Planetary Decadal Survey is at risk of being bound in the shallows.

OPAG urges NASA to bring the Outer Planets Research selection rates up to a level consistent with other core R&A programs and selection rates up overall. Dr. McKinnon noted that the CDAP selection rates promise to be similarly low; OPAG notes that the nation is not fully reaping the benefits of a considerable investment. Dr. Sykes commented that PSD has in effect made a policy decision to reduce R&A. Dr. Grant added that his impression is that R&A funding gets lowest priority, despite the Decadal Survey calling it out as a top priority.

OPAG finds that progress is measured but steady in the effort to re-start domestic Pu-238 production. OPAG finds that NASA should continue to do what is necessary to continue the

Planetary Science Subcommittee Meeting, October 2-3, 2012

effort, and further supports making ASRGs available for the next Discovery and New Frontiers calls.

The strong majority view of the OPAG community is that the Europa “clipper” option offers the greatest science return per dollar, and looks forward to hearing results of enhanced mission and solar power options studies in January. Dr. McKinnon commented pointedly that when the Europa SDT stands down, the NASA Europa effort ends.

An Io Workshop report, held in July 2012, discussed progress on an Io geologic map, and geochemical and computer modeling of the Jovian satellite, as well as the “Future of Io Exploration.” The workshop participants suggested including the Io Observer and Lunar Geophysical Network in NF-4 selection (rather than waiting until NF-5), but OPAG does not support this; the OP community appears to be frustrated that there is no money to fund Flagship missions. Even with a NASA provided launcher and ASRG, the Outer Planets remain out of reach.

Dr. McKinnon reviewed recent science findings, such as the detection of a sub-surface ocean on Titan; Cassini gravity measurements of large solid tides are indicative of a liquid water ocean under Titan’s ice shell; this ocean may serve as a reservoir to replenish methane in Titan’s atmosphere. Data also indicate that Titan’s polar hood moves south; and there seems to be a polar vortex with down-welling. Images of Uranus were displayed, revealing both aurorae and clouds and haze. Iapetus, a moon of Saturn with a distinct equatorial ridge, has been seen to have huge ice avalanches, which point to low friction mechanism on the moon.

SBAG report

Dr. Mark Sykes reported on the Small Bodies Analysis Group (SBAG), which held its most recent meeting in the summer of 2012. SBAG discussed potential impacts of the President’s FY2013 budget, the health of the Discovery program, the New Frontiers program status, a report from the Roadmap Action Team (identifying goals for SB exploration and sample requirements flow-down), status and plans for the Near-Earth Objects Observation (NEOO) program, participation in the P-SAG, and contributions of the SBAG to Phobos/Deimos requirements. The group engaged in identifying SKGs for human exploration to NEOs and Phobos/Deimos; heard status reports on Dawn, OSIRIS-REX, Hayabusa, Rosetta, New Horizons and NEOCAM. It also heard presentations from B612 and Planetary Resources, Inc., both of which are commercial concerns interested in asteroid exploration. SBAG members participated in a planetary balloon workshop, focusing on studying asteroids and comets, and on small bodies mission planning tools being made available through NASA’s Glenn Research Center. SBAG has requested a series of regular reports from the Planetary Data System (PDS) on the status of small bodies-related PDS holdings (new data, tools, etc.) to forge better connections with the PDS Small Bodies Node.

SBAG’s findings include an expression of concern with Discovery program, which has essentially collapsed. The implementation of the Planetary Decadal Survey requires a 24-month cadence for Discovery. SBAG is concerned that NASA may be allocating significant resources (a maximum of \$2-3M per year for 10 years) to support the private efforts of B612, and would like to see more transparency in the process. SBAG is therefore setting up a Specific Action Team to assess the implications. A NASA representative commented that the commercial effort reflects a request to NASA for Deep Space Network (DSN) communications support, as well as technical support from experts at the Agency; NASA will determine whether this venture is in the interest of the Agency and the general public. The B612 mission has a potential of returning data on several thousand NEOs per year. Dr. Luhmann suggested using SALMON as a vehicle for NEO

Planetary Science Subcommittee Meeting, October 2-3, 2012

needs. The NASA representative noted that NASA is not giving any funds to B612; the funding is for NASA itself to do what it needs to do to carry out the support.

Dr. Sykes enumerated the remainder of SBAG findings:

- SBAG reaffirms support for the high scientific value of sample return
- SBAG endorses recommendations relevant to Phobos/Deimos that emerged from the PSAG report, particularly recommending remote and *in situ* observations at one or both moons prior to human arrival, to address SKGs
- SBAG is concerned that SKGs be prioritized by engineers, technologists, and scientists
- SBAG supports SKG investigations include science priorities

SBAG is currently working through NEO and Phobos/Deimos SKGs through a specific SAT, particularly noting ISRU. SBAG is pleased that the current Cooperative Agreement Notice (CAN) for the NASA Research Institute for Science and Exploration includes consideration of small bodies, and is also pleased about the 50-50 contribution by HEOMD; SBAG recommends including SKGs in the CAN. Dr. Sykes questioned, however, whether an institute the most cost-effective way to do science and requested a budget breakdown of institute activities. Dr. Shearer felt that the NLSI in the past has successfully grown the community and has brought in fresh ideas, allowing substantial opportunities for collaboration. Some argued that people who are part of the institute are already present on missions. SBAG is questioning the utility of the NRO telescope for NASA purposes, and is beginning to discuss what aspects would be advantageous for the different, relevant AGs in contemplating a dedicated planetary telescope. Dr. Sykes observed that discussions within SMD center around advancing Astrophysics goals.

Science findings from the SBAG include evidence that comets are not in fact arising from the Kuiper Belt, as well as new data from Deep Impact and AKARI. Modeling of Vesta's two large basins reveal that troughs on Vesta are evidence of tectonics, and its differentiated interior could affect impact-related stresses. Hydrogen has been found on the upper meter of Vesta by Dawn's GRaND (gamma ray and neutron detector) instrument.

VEXAG

Dr. Limaye presented the latest activities of the Venus Exploration Analysis Group (VEXAG). The June 2012 Venus transit was well covered all over the world through observations acquired by both space- and ground-based assets. The Comparative Climatology of Terrestrial Planets (CCTP) Conference was supported by all four NASA SMD divisions in July 2012. A Committee on Space Research (COSPAR) meeting took place in July in India, where an international Venus Working Group was proposed and is now being formed. A Venus workshop was conducted with international presenters at the Indian Institute of Space Science and Technology (IIST), with 30 participants from 6 Indian Space Research Organization (ISRO) centers. An issue of the VEXAG newsletter was published, wherein it was noted that Dr. Janet Luhmann had received the COSPAR Space Science Award in July.

CCTP outcomes include a decision to maintain an *ad hoc* CCTP steering committee, a decision to publish a topical book in Fall 2013, as well as a proposal for a Comparative Climatology ROSES element to investigate terrestrial planetary climates; he added that there is a need for continuous long-term measurements of the Solar System's terrestrial planets. CCTP also considered the possibility of a joint interdisciplinary Comparative Climatology program between NSF and SMD. A follow-up CCTP2 meeting is scheduled for 2015.

Planetary Science Subcommittee Meeting, October 2-3, 2012

The next VEXAG meeting will be held 13-15 November, and includes on its agenda an update of its Goals, Objectives and Investigations document, in light of new Venus Express data. There will be a Venus Upper Atmosphere Investigations Science and Technical Interchange Meeting (STIM) at the Glenn Research Center in January 2013, to help further develop strategic science objectives for Venus. There is community support for updating the Venus Reference Model(s); the first model having been developed in 1985.

Venus Express still making discoveries, and will continue an extended mission through the end of 2014; most data are now available through PDS/PSA. The recovered Japanese spacecraft Akatsuki will approach Venus in 2015, in a close fly-by followed by long equatorial orbit in 2016.

ISRO announced a preliminary study of a Venus orbiter in February 2012.

Dr. Limaye displayed images of coronagraphic studies during the Venus transit and reported the presence of a cold region discovered on Venus by Venus Express' SOIR instrument.

MESSENGER update

Dr. Prockter gave a short briefing on MESSENGER, in response to a discussion that arose from earlier questions about the Planetary Senior Review. Dr. Prockter reviewed MESSENGER's trajectory profile. The spacecraft has enough fuel to carry out four orbital correction maneuvers for two additional years, however funding for the mission runs out in March 2013. Most instruments are in good to excellent health, and the spacecraft is in good condition. An extended mission would enable MESSENGER to make measurements through the next solar maximum. Dr. Prockter reported having spoken to Dr. Green, who is considering options.

OSIRIS-REx

Dr. Gordon Johnston presented an update on the Origins Spectral Interpretation Resource Identification Security Regolith Explorer Science (OSIRIS-Rex) mission. The mission's primary goal is to return a sample from pristine carbonaceous asteroid regolith, and can also provide an opportunity to measure the Yarkovsky effect on a potentially hazardous asteroid. OSIRIS-Rex is a 7-year mission spanning launch to return. The mission is scheduled to launch in 2016, planning to arrive at 2019. The instruments include a camera suite, with multiple cameras calibrated for both distance and for close range (for sampling), a laser altimeter (Canada); a visible and IR spectrometer, radio science, and a REXIS instrument (regolith x-ray image spectrometer; Harvard and MIT). A "pogo stick" approach will be used to find a sample area, and regolith will be acquired by nitrogen gas evacuation of a chamber. Of primary concern is the Canadian collaboration, which is on a tight schedule due to a delay in funding.

Workplace survey

Dr. Frances Bagenal presented a briefing on the demographics of the Planetary Science community, and discussed implications for future planetary scientists, academia, NASA labs, and industry. On personal initiative, Dr. Bagenal surveyed academic departments (teaching faculty) across the U.S., as well as active scientists (largely members of AGU, DPS, and attendees of LPSC), noting that some departments did not respond to the survey. The survey found that women are very unrepresented in the community, and that men tend to apply for more faculty positions than women do. Women are more likely to be hampered by a "two-body problem;" i.e. the presence of a woman's significant other presents a special challenge in terms of career mobility.

Overall, this relatively informal survey found 229 PS faculty, 75-131 PhDs per year, replacement

Planetary Science Subcommittee Meeting, October 2-3, 2012

rate about 8 per year, means 1 in 10 gets a faculty position, more like 1 in 8. Roughly 206 Bachelor degrees per year were awarded in disciplines associated with the planetary sciences.

A Part B survey was carried out more rigorously with AIP, which sent surveys to 5252 individuals, garnering a 62% response. Of the 2622 respondents, 1518 (58%) have Ph.D.s and live in the U.S. The median age for men in this group was 48, and for women, 38. Both the surveyed planetary scientists and nonplanetary scientists work in universities for the most part. Salary vs. soft funding patterns were not surveyed. Most respondents reported having done post-doctoral work. Undergraduate majors were largely represented in physics. The doctorate field was much more populated by planetary science and geology/geophysics. Respondents reported that doctoral programs suffered from a lack of experience in preparing candidates for nonacademic careers and managing people. Areas that could have benefited from more training included experience in proposal writing. As to sources of funds to support research, 53% reported NASA funding only, while 15% reported both NASA and NSF support.

Regarding the “two-body problem,” Dr. Bagenal noted that relatively few men have partners who work in the sciences; however most female scientist have partners who work in the sciences, and further noted that institutions should consider how to help women re-enter the field after child-rearing.

Follow-up questions for this survey might well include more detailed information on both graduate and undergraduate students from major universities. Other useful questions include: How large should the planetary community be? How do employers view the workforce. How many study planetary science but do not pursue it past the academic stage? How many underemployed Ph.D.s are there in planetary science? It would also be useful to query institutions that grant the most Ph.D.s. The survey did not include civil servants specifically, but Dr. Bagenal did tally those numbers where possible. Dr. Castillo-Rogez recommended a comparison of this survey with the National Research Council’s (NRC’s) 2007 survey of the NASA workforce. Dr. Sykes commented that because planetary science is unique to NASA, the Agency needs to worry about the workforce. Dr. Bagenal noted that as PSD’s Dr. Green had funded the survey, a recommendation from PSS might be valuable.

R&A Update

Dr. Max Bernstein provided an update on R&A statistics for SMD in 2011. Planetary R&A is still not doing well, but he pointed out that budgets remained unknown until March 2012, although triage letters had been sent out in October/November 2011. Dispersal-of-budget issues remains an issue for PSD, unlike the Astrophysics Division (APD), which receives a large percentage of its budget in October/November. Dr. Sunshine noted that PSS had made a recommendation in May 2012 to have PSD follow APD’s practice. Dr. Bernstein and Dr. Voytek discussed various aspects of the funding difficulties. Dr. Sykes urged that PSD commit to the Decadal Survey recommendation of providing \$230M for Planetary R&A. Dr. Rall noted that in FY12, R&A was in fact given \$242M. Dr. Voytek commented that the Decadal Survey had planned to a very unrealistic budget; Dr. Green’s response to this situation was to pledge to hold R&A steady. Dr. Sykes claimed that R&A had been raided to fund MSL; members generally agreed that PSS should re-affirm its previous finding.

Dr. Bernstein displayed selection statistics as of September 2012, which hover in the 20-percent range; this percentage reflects Kelly Fast’s method of quickly selecting, then going back to the pool of candidates and making selections later in the year. PSD is still compiling data on the two-step approach that has been adopted for CDAP. PSD is also piloting combining review panels for some programs; and as a result has created a low-TRL program called Picasso, and a TRL 4-6

Planetary Science Subcommittee Meeting, October 2-3, 2012

program called Matisse. Dr. Rall noted that PSD will also need to deal with disappearing lunar funds and will have to find a way to cover the added requirements.

NRC-CAPS Update

Dr. Phil Christensen, co-chair of the Committee on Astrobiology and Planetary Science (CAPS), briefed PSS. CAPS is a single NRC committee for astrobiology and planetary science and is considered to be the “keeper of the Decadal Survey.” CAPS’s 18 members are widely represented in the relevant sciences. Of recent concern to CAPS is the 20% reduction in the latest PSD budget, resulting in a nearly empty pipeline of missions. The Mars Exploration Program budget has been reduced by 35%, therefore the Mars program is not healthy, and little is being done for the future. In this budget atmosphere, PSD will be unable to implement Decadal Survey recommendations for a balanced program of mission classes and destinations. Of particular concern is the virtual elimination of Flagship missions. CAPS supports the Mars and Europa re-planning effort, which at the very least keeps the scientific underpinnings in place.

CAPS feels that MPPG’s recommendation for a Mars rover, in particular Rover B with its sophisticated caching ability, has significant advantages over an orbiter for 2018; there is no compelling need to refresh communications assets, as there are currently three orbiters at Mars and two in development. MSL hardware and expertise exists now; a delay would risk loss of Mars EDL capability. The year 2018 is a favorable launch opportunity, and a heavier rover can be sent to the surface with a smaller launch vehicle. Orbital communications will need to be replaced by 2022, according to the MPPG. CAPS supports the MPPG conclusion that sample return is the logical next step in Mars exploration, broadening the base of support into HEOMD and OCT. Dr. Sykes commented that the James Webb Space Telescope (JWST) will trump the Astrophysics Decadal Survey because it is a NASA priority; Mars will make the rest of planetary priorities distantly secondary, just as JWST did for Astrophysics. Dr. Christensen shared this concern but did not feel it was inevitable. Dr. Luhmann commented that there is some concern that funding has not appeared from HEOMD and OCT in support of the Mars effort. Dr. Christensen felt that NASA would need to reinstate Mars program funding to where it has been in the last decade, prior to the 35% cut. Dr. Luhmann recommended that PSD keep an eye on the expansion of requirements levied from other directorates without provision of resources. Dr. Limaye expressed concern that PSD is getting too focused on Mars; there has been no mission to Venus since 1992. Dr. Christensen noted that the percentage of PSD devoted to Mars remains unchanged, and public engagement is strong- the money could go away if NASA abandons Mars.

CAPS expressed admiration for NASA’s work on developing a robust, feasible Clipper mission to Europa. CAPS favors the Clipper as it addresses the science objectives of Decadal Survey, and has no significant overlap with JUICE. In addition, radiation issues have been well addressed, and the solar power option appears to be feasible based on the Juno experience. High-resolution imaging, if reasonable, would be an excellent feed-forward option to support a future lander mission. CAPS has concluded that Astrobiology remains in good health despite prior budget cuts, however the committee remains concerned about the PSD budget reduction, implementation of Decadal Survey, the Mars program, and the future of international cooperation. If requested, CAPS can carry out an official review and report on MPPG and the Europa study. CAPS makes no findings or recommendations, but can list concerns.

Preliminary Findings

Dr. Sunshine suggested that as topics haven’t changed, PSS might reiterate its 7 findings from its previous meeting:

Planetary Science Subcommittee Meeting, October 2-3, 2012

Support PSD efforts to restore funding PI-led programs, Discovery and New Frontiers.

Support Coordination of HEOMD/OCT/SMD toward long-term exploration of Mars (also exploration of the Moon)

Support NASA participation in JUICE and de-scoped Europa

Support NASA efforts of Pu-238/ASRG development and validation for flight-readiness

Support commitment of R&A funding/program budgeting early in the fiscal year by the PSD Division Director, and get a status update from the Director on these commitments

Recommend additional staffing for R&A program management

Encourage PSD efforts to communicate its accomplishments to the public

Dr. Gregg Vane suggested adding a comment on MPPG. Dr. Christensen applauded the efforts on cost reduction in both Mars and Europa mission reformulations/de-scopes. Dr. Luhmann was particularly struck by the presence of Mars Sample Return in MPPG's consideration, and adherence to the Decadal Survey. Dr. Des Marais agreed to provide some rewording on finding #2. Dr. Luhmann was struck by the high presence of international instruments on Discovery missions; implying perhaps that there is not enough NASA money for the mission. Dr. Vane commented that NASA is providing mechanical and thermal protection for the seismometer. Dr. Prockter suggested making the dearth of U.S. instrumentation an agenda item for the next meeting. Dr. Limaye suggested adding a concern about balance to finding #2. Committee members supported a review by CAPS on how PSD follows the Decadal Survey.

The next PSS meeting was planned for late February 2013.

Appendix A
Attendees

Subcommittee Members

Janet Luhmann, Chair PSS, University of California, Berkeley

James Bell, Carnegie Institute of Washington

Julie Castillo-Rogez, NASA Jet Propulsion Laboratory

David Des Marais, NASA Ames Research Center

John Grant, Smithsonian Institution

Sanjay Limaye, University of Wisconsin

Louise Prockter, Johns Hopkins University

William B. McKinnon, Washington University

Anna-Louise Reysenbach, Portland State University

Charles Shearer, University of New Mexico

Paul Steffes, Georgia Institute of Technology

Jessica Sunshine, University of Maryland

Mark V. Sykes, Planetary Science Institute

Meenakshi Wadhwa, Arizona State University

Jonathan A. R. Rall, Executive Secretary, NASA HQ

NASA Attendees

Waleed Abdalati, NASA HQ

Marc Allen, NASA HQ

Max Bernstein, NASA HQ

Janice Buckner, NASA HQ

John Cooper, NASA GSFC

Leonard Dudzinski, NASA HQ

T. Jens Feeley, NASA HQ

Kristen Erickson, NASA PSD

Kelly Fast, NASA HQ

Chris Flaherty, NASA HQ

Mike Garcia, NASA HQ

Michelle Gates, NASA HQ

Lori Glaze, NASA GSFC

Ed Grayzeck, NASA HQ

Jeff Grossman, NASA HQ

Lindley Johnson, NASA HQ

Jennifer Kearns, NASA HQ

Bill Knopf, NASA HQ

Tibor Kremic, NASA HQ

Doug McCuiston, NASA

Marian Norris, NASA HQ

Sarah Noble, NASA HQ

Curt Niebur, NASA HQ

Adriana Ocampo, NASA HQ

Lilian Reichenthal, NASA HQ

Planetary Science Subcommittee Meeting, October 2-3, 2012

Joan Salute, NASA PSD
Mitch Schulte, NASA HQ
David Senske, JPL/NASA
Heather Smith, NASA HQ
Falguni Suthar, NASA ARC
Gregg Vane, NASA JPL
Richard Vondrak, NASA GSFC
Mary Voytek, NASA HQ
Dan Woods, NASA SMD
Michael Wargo, NASA ESMD
Richard Zurek, JPL/NASA

Non-NASA Attendees

Linda Billings, George Washington University
Francesco Bordi, Aerospace Corporation
Kaitlin Chell, Caltech
Anne Connor, House Science Space and Technology Center
Dom Conte, Orbital Sciences
Andrew Duncan, USN
Walt Falconer, SSS
Orlando Figueroa, OLELLC
David Gump, Deep Space Industries
Steve Mackwell, USRA-LPI
John Malay, Lockheed Martin
Miriam Quintal, Caltech
Nick Smith, Lockheed Martin
Joan Zimmermann, Zantech IT

Planetary Science Subcommittee Meeting, October 2-3, 2012

Appendix B
Membership Roster
Planetary Science Subcommittee

Janet Luhmann (Chair)

Senior Fellow
Space Sciences Laboratory
University of California, Berkeley

Julie Castillo-Rogez
Jet Propulsion Laboratory

David Des Marais
NASA Ames Research Center

John Grant
National Air and Space Museum
Smithsonian Institution

Sanjay Limaye
Space Science and Engineering Center
University of Wisconsin

Jonathan A. R. Rall, Executive Secretary

Research & Analysis Program - Lead
Planetary Science Division
Science Mission Directorate

William B. McKinnon
Department of Earth and Planetary Sciences
Washington University

Louise Prockter
Department of Space Physics
Johns Hopkins University

Anna-Louise Reysenbach
Portland State University
Department of Biology

Planetary Science Subcommittee Meeting, October 2-3, 2012

Charles Shearer
Institute of Meteoritics
University of New Mexico

Paul Steffes
School of Electrical and Computer Engineering
Georgia Institute of Technology

Jessica Sunshine
Department of Astronomy
University of Maryland

Mark V. Sykes
CEO and Director
Planetary Science Institute

Meenakshi Wadhwa
Director
Center For Meteorite Studies
Arizona State University

Subcommittee Administrative Support:

Ms. Marian R. Norris
Management Support Specialist
Science Mission Directorate
NASA Headquarters

Planetary Science Subcommittee Meeting, October 2-3, 2012

Appendix C

List of Presentation Materials

1. Planetary Science Division Status and Update, *Joan Salute*
2. Mars Exploration Program Status, *Douglas McCuiston*
3. Mars Science Lander/Curiosity Update, *James Bell*
4. Mars Program Planning Group, *Orlando Figueroa*
5. Europa Study Update, *David Senske*
6. Discovery Update/InSight, *Mitch Schulte*
7. PSD Senior Review Status/Outcome, *William Knopf*
8. CAPTEM Report, *Meenakshi Wadwha*
9. MEPAG Report, *David Des Marais*
10. LEAG Report, *Charles Shearer*
11. OPAG Report, *William McKinnon*
12. SBAG Report, *Mark Sykes*
13. VEXAG Report, *Sanjay Limaye*
14. MESSENGER Projected Trajectory, *Louise Prockter*
15. OSIRIS-Rex Overview, *Gordon Johnston*
16. Planetary Science Workforce Survey, *Frances Bagenal*
17. NRC-CAPS Update, *Phil Christensen*
18. Research and Analysis Update, *Jonathan Rall, Max Bernstein*

Planetary Science Subcommittee Meeting, October 2-3, 2012

Appendix D Agenda

Planetary Science Subcommittee Meeting

October 2-3, 2012
NASA Headquarters
Washington D.C.

2 October (8:30-5:30, Room 9H40)

- 8:30 Welcome, agenda, announcements (Luhman, Salute, Rall)
- 8:45 PSD status update including FY13 budget changes (Salute)
- 9:30 Mars Program Status update (McCuistion)
- 10:15 Break
- 10:30 MSL/Curiosity update (Bell)
- 11:30 Lunch (on own)
- 1:00 Mars Program Planning Group (MPPG) Briefing (Figueroa)
- 2:00 Europa Study update (Senske)
- 2:45 Discovery Update – InSight (Schulte/DePaula)
- 3:15 Break
- 3:30 PSD Senior Review status/outcome (Knopf/Grayzeck)
- 4:00 GPRA discussion/scoring (Rall/Kearns)
- 5:30 Adjourn
- 6:30 Group Dinner (TBD)

3 October (8:30-4:30, Room 9H40)

- 8:30 Agenda updates & announcements (Luhman, Salute, Rall)
- 8:45 CAPTEM report (Wadhwa)
- 9:15 MEPAG report (Des Marais)
- 9:45 LEAG report (Shearer)
- 10:15 Break
- 10:30 OPAG report (McKinnon)
- 11:00 SBAG report (Sykes)
- 11:30 VEXAG report (Limaye)
- 12:00 Lunch (on own)
- 1:00 Workforce Survey (Bagenal)
- 2:00 NRC-CAPS Update (Christensen)
- 3:00 R&A Update (Rall)